# NAVAL POSTGRADUATE SCHOOL
# Monterey, California

# THESIS

**GLOBAL BROADCAST SERVICE REACH BACK VIA SATELLITE TACTICAL DIGITAL LINK J (S-TADIL J)**

by

Sandra J. Fenton

September 1999

| | |
|---|---|
| Thesis Advisor: | Rasler W. Smith |
| Associate Advisor: | Rex A. Buddenberg |

**Approved for public release; distribution is unlimited.**

# REPORT DOCUMENTATION PAGE

*Form Approved OMB No. 0704-0188*



| 1. AGENCY USE ONLY *(Leave blank)* | 2. REPORT DATE | 3. REPORT TYPE AND DATES COVERED |
|---|---|---|
| | September 1999 | Master's Thesis |

**4. TITLE AND SUBTITLE :**
GLOBAL BROADCAST SERVICE REACH BACK VIA SATELLITE TACTICAL DIGITAL LINK (S-TADIL J)

**5. FUNDING NUMBERS**

**6. AUTHOR**
Fenton, Sandra J.

**7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)**
Naval Postgraduate School
Monterey, CA 93943-5000

**8. PERFORMING ORGANIZATION REPORT NUMBER**

**9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)**
N/A

**10. SPONSORING / MONITORING AGENCY REPORT NUMBER**

**11. SUPPLEMENTARY NOTES**
The views expressed in this thesis are those of the author and do not reflect the official policy or position of the Department of Defense or the U.S. Government.

**12a. DISTRIBUTION / AVAILABILITY STATEMENT**
Approved for public release; distribution is unlimited.

**12b. DISTRIBUTION CODE**

**13. ABSTRACT** ***(maximum 200 words)***
To meet the increasing need for additional wideband satellite capability within the Department of Defense, the Global Broadcast Service (GBS) is being developed. GBS is an asymmetric network providing up to 24 Mbps from the Satellite Broadcast Manager (SBM) to deployed forces via UHF Follow On (UFO) satellites during GBS Phase Two. The concept of Smart Push provides for most of the users' needs but cannot anticipate every need or emerging needs of the user. The user through User Pull requires the ability to request information products from the SBM through existing communication paths. This capability is termed reach back. Due to the nature of operations, not as much information is sent back from operating forces to headquarters commands; therefore, less bandwidth is required from deployed forces to headquarters commands. Reach back channels do not require as much bandwidth as GBS. This research explores the viability of using Satellite Tactical Digital Link J (S-TADIL J), also known as Satellite Link 16, as a reach back option for GBS.

**14. SUBJECT TERMS**
Global Broadcast Service, GBS, Link 16, Satellite Tactical Digital Link J, S-TADIL J

**15. NUMBER OF PAGES**
78

**16. PRICE CODE**

| 17. SECURITY CLASSIFICATION OF REPORT | 18. SECURITY CLASSIFICATION OF THIS PAGE | 19. SECURITY CLASSIFICATION OF ABSTRACT | 20. LIMITATION OF ABSTRACT |
|---|---|---|---|
| Unclassified | Unclassified | Unclassified | UL |

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. 239-18

**Approved for public release; distribution is unlimited.**

**GLOBAL BROADCAST SERVICE REACH BACK VIA SATELLITE TACTICAL DIGITAL LINK J (S-TADIL J)**

Sandra J. Fenton
Lieutenant Commander, United States Navy
B.G.S., University of Kansas, 1986

Submitted in partial fulfillment of the
requirements for the degree of

**MASTER OF SCIENCE IN INFORMATION TECHNOLOGY MANAGEMENT**

from the

**NAVAL POSTGRADUATE SCHOOL**

**September 1999**

Author: S. J. Fenton
Sandra J. Fenton

Approved by: Rasler W. Smith
Rasler W. Smith, Advisor

Rex A. Buddenberg, ~~Associate~~ Advisor

Dan C. Boger
Dan C. Boger, Chair
Information Systems Academic Group

## ABSTRACT

To meet the increasing need for additional wideband satellite capability within the Department of Defense, the Global Broadcast Service (GBS) is being developed. GBS is an asymmetric network providing up to 24 Mbps from the Satellite Broadcast Manager (SBM) to deployed forces via UHF Follow On (UFO) satellites during GBS Phase Two. The concept of Smart Push provides for most of the users' needs but cannot anticipate every need or emerging needs of the user. The user through User Pull requires the ability to request information products from the SBM through existing communication paths. This capability is termed reach back. Due to the nature of operations, not as much information is sent back from operating forces to headquarters commands; therefore, less bandwidth is required from deployed forces to headquarters commands. Reach back channels do not require as much bandwidth as GBS. This research explores the viability of using Satellite Tactical Digital Link J (S-TADIL J), also known as Satellite Link 16, as a reach back option for GBS.

## TABLE OF CONTENTS

# LIST OF FIGURES

# LIST OF TABLES

# I. INTRODUCTION

## A. BACKGROUND

*The Conduct of the Persian Gulf War--The Final Report to Congress*, April 1992 highlighted the DoD need for alternate wideband satellite communications. The Gulf War drew attention to the fact that not enough satellite bandwidth was available to the DoD and that it lacked redundancy. Since then, the need for wideband satellite communications has increased with the advancements brought about by the Information Age. This is true in the private sector as well where the need for additional bandwidth will be met by systems such as Teledesic, a wideband satellite communications constellation that should become operational in 2004. [Ref. 1]

Joint tactical operations require high speed, multimedia communications and information flow to in-transit or deployed mobile forces. Deployed units normally require more information for mission performance than is required for return transmission resulting in an asymmetric flow of information. [Ref. 2]

Existing military satellite communications systems are oversubscribed and were neither designed for nor configured to provide high capacity broadcast service. As a result, a high capacity broadcast capability is needed to provide timely dissemination of information products such as imagery, intelligence information, missile warning, weather, record message traffic, joint and service-unique news, education, training, video, Morale Welfare & Recreation (MWR) programming, telemedicine and other desired information. The implementation of the Global Broadcast Service (GBS) will provide worldwide, high

capacity, one-way transmission of a variety of high-speed computer-to-computer data updates, high quality imagery, and other information products to supported forces. [Ref. 2] Table 1. below illustrates the difference in bandwidth and delivery times for existing DoD systems compared to GBS. GBS will improve information transfer to deployed units and free demand on existing systems.

| | Existing DoD SATCOM Systems Limit Supported Communications Capacity | | | | |
|---|---|---|---|---|---|
| SATCOM Throughput / Example Information | 2.4 Kbps **Milstar & UFO** | 64 Kbps **LOCE** | 512 Kbps **SIPRNET** | 1.544 Mbps **Milstar MDR** | 23 Mbps **<u>GBS</u>** |
| **Air Tasking Order (DS)** 1.1 Mb | 1.02 hr | 2.61 min | 17.19 sec | 5.7 sec | 0.38 sec |
| **Tomahawk MDU** 0.03 Mb | 100 sec | 4.29 sec | 0.47 sec | 0.16 sec | 0.01 sec |
| **Imagery 8x10 Annotated** 24 Mb | 22.2 hr | 57 min | 6.25 min | 2.07 min | 8.4 sec |
| **DS TPFDD (log support)** 250 Mb | 9.65 day | 9.92 hr | 1.09 hr | 21.59 min | 1.45 min |
| Larger Throughput = Faster Dissemination = Better Service to the Warfighter | | | | | |

Table 1. Greater Bandwidth Provided by GBS

[Ref. 3]

## B. HUGHES ELECTRONICS CORPORATION

GBS is an adaptation of DIRECTV® and DirecPC to DoD. DIRECTV, a unit of Hughes Electronics Corporation, launched service in the summer of 1994. According to industry statistics, the DIRECTV System has become the fastest selling consumer electronics product ever to enter the market -- faster than color TVs, CD players, or VCRs. DIRECTV is the nation's leading digital television service with more than 7.4 million subscribers. During the first six months of 1999, year-to-date growth in number of subscribers is up 48% for DIRECTV. A June 1999 alliance between America On Line (AOL) and Hughes Electronics Corporation will enhance the development of Hughes' next-generation satellite system for two-way, broadband connectivity, known as Spaceway®, scheduled to launch in 2002. Hughes previously announced a $1.4 billion investment to design, manufacture and launch the North American system and accompanying ground infrastructure. [Ref. 4]

### 1. DIRECTV

DIRECTV provides television and music channels via satellite to geographic areas where cable television is not accessible or affordable or the user prefers satellite television over cable. The subscriber's system consists of a small 18-inch satellite dish to receive the satellite broadcast signal; a digital integrated receiver/decoder (IRD), which separates each channel, and decompresses and translates the digital signal so a television can show it; and a remote control.

DIRECTV programming is distributed by three high-power HS 601 satellites (DBS-1, DBS-2, and DBS-3) built by Hughes Electronics. Each satellite features 16 120-watt Ku-band transponders with DBS-2 and DBS-3 each configured to provide 8 transponders at 240 watts. DBS-1 delivers up to 60 channels of DIRECTV programming and over 20 channels of programming from USSB®. DBS-2 and DBS-3 are used exclusively by DIRECTV to bring the service up to its current capacity of over 175 channels. All three satellites are co-located in geosynchronous orbit 22,300 miles above the earth at 101° West longitude. [Ref. 4]

To gather programming content, ensure its digital quality, and transmit the signal up to the satellites, DIRECTV created a digital broadcast center in Castle Rock, Colorado. It is operational 24-hours a day, seven days a week, with a total on-site staff of approximately 180 people. [Ref. 4]

Programming comes to the broadcast center from content providers (e.g., CNN, ESPN) via satellite, fiber optic cable and/or special digital tape. Most satellite-delivered programming is immediately digitized, encrypted, and uplinked to the orbiting satellites. The DBS satellites retransmit the signal back down to every receiver dish at subscribers' homes and businesses. [Ref. 4]

### 2. DirecPC/DirecDuo

DirecPC, part of Hughes Network Systems, provides satellite-based, broadband, Internet download delivery to subscribers. DirecPC provides download speeds up to 400 kilobits per second (Kbps) or 15 times faster than a 28.8 Kbps modem. A large down

link capability is available through DirecPC; however, the subscriber sends information via a modem and telephone line. DirecDuo provides the capability offered by both DIRECTV and DirecPC by enabling subscribers to access the DIRECTV and DirecPC networks with a single 21-inch elliptical satellite dish. [Ref. 5]

## C. PURPOSE OF RESEARCH

GBS is based on the concept of Smart Push and User Pull. In order for a particular unit to obtain needed data that is not being broadcast over GBS, the unit requests the data (User Pull) from the Satellite Broadcast Manager (SBM). To order a movie or special program via DIRECTV, the subscriber uses a telephone line plugged into the IRD and selects the movie or program via the on screen menu using the remote control. The selection is completed almost instantaneously. With GBS, this parallel requirement exists but usually cannot be accomplished via a telephone line (e.g., a deployed ship). When a telephone is used for GBS User Pull, human-to-human interaction is required instead of subscriber to automated system as in DIRECTV. The User Pull avenue in GBS is termed reach back. Several alternatives are being examined as possible reach back options for GBS. The purpose of this research is to determine if Satellite Tactical Digital Link J (S-TADIL J) is a viable reach back option for GBS.

## D. SCOPE OF THESIS

The scope of this research is limited to naval ships in the Pacific area of responsibility (AOR). The initial fielding and prototype operations of GBS are taking place in the United States Pacific Command (USPACOM). UFO-8 is the first satellite

providing data via GBS in the Pacific AOR to a shipboard receive suite aboard the USS CORONADO.

## E. THESIS ORGANIZATION

A background on GBS is given including the three phases of implementation. The path of the signal and the requirement for a reach back capability are described followed by reach back experiments and research that have taken place so far. A description of S-TADIL J is followed by implementation of S-TADIL J in the Fleet and a listing of which units utilize S-TADIL J. An experiment description is provided for using S-TADIL J as a reach back channel for GBS. Recommendations for further study are then given.

# II. GLOBAL BROADCAST SERVICE

## A. GBS OVERVIEW

With the recognition by DoD that greater satellite bandwidth is needed by the operating forces, on 8 August 1995, the Joint Requirements Oversight Council (JROC) validated the Mission Need Statement (MNS) for GBS. GBS was designated as a joint program on 27 March 1996, by direction of the Under Secretary of Defense for Acquisition and Technology (USD(A&T)). On 7 April 1997, the JROC approved the Phase II requirements contained in the Operational Requirements Document (ORD) and validated the Phase 2 Key Performance Parameters (KPP). The space segment assets of GBS have three phases of fielded capability. The GBS Joint Concept of Operations, Version 2.0 was issued on 31 December 1997, and the Theater Injection Point (TIP) Concept of Operations was issued on 19 May 1999. GBS support to the warfighter began in March 1999 with the broadcast of Unmanned Aerial Vehicle (UAV) video to the USS CORONADO. [Ref. 6] In addition to the Shipboard Receive Suite (SRS) onboard the USS CORONADO, Fixed Ground Receive Suites (FGRS) have been fielded to the Joint Intelligence Center Pacific (JICPAC) and six United States Forces Korea (USFK) locations. [Ref. 6] Initial operational capability for Phase Two of GBS is March 2001, and full operational capability is FY 2004.

## B. HOW GBS WORKS

Operating forces need various information products such as weather, mapping, imagery, intelligence, Air Tasking Orders (ATO), data bases, software updates, Armed Forces Radio and Television System (AFRTS), commercial cable news or weather services, modeling and simulation information, common tactical picture situational awareness products, medical, logistics, distance learning or training, and other desired broadcasts that require higher bandwidths. These products can be video and data. [Ref. 7] As the Information Age continues this need will increase. The producers of these information products supply them to the SBM, which collects information from various sources, packages the information for broadcast, and finally, broadcasts the information over GBS. A point of emphasis is that GBS is an extension of the Defense Information Infrastructure (DII); the information products should reach the SBM over the DII. GBS provides a scalable architecture through configuration of the satellite payload and number and types of receive suites.

The Primary Injection Point (PIP) is co-located with the SBM at a Naval Computer and Telecommunications Area Master Station (NCTAMS) or Naval Computer and Telecommunications Station (NCTS). The PIP is located within each satellites' field of view (FOV) and is where the broadcast stream is uplinked to the satellite. The PIP consists of an 26-ft diameter, 47-ft high satellite antenna and associated equipment; it can transmit up to four 24 Mbps signals to the satellite and transmits in the Extremely High Frequency band between 30 and 31 GHz. [Ref. 6] The SBM and PIP for UFO-8 are shown in Figure 1 below.

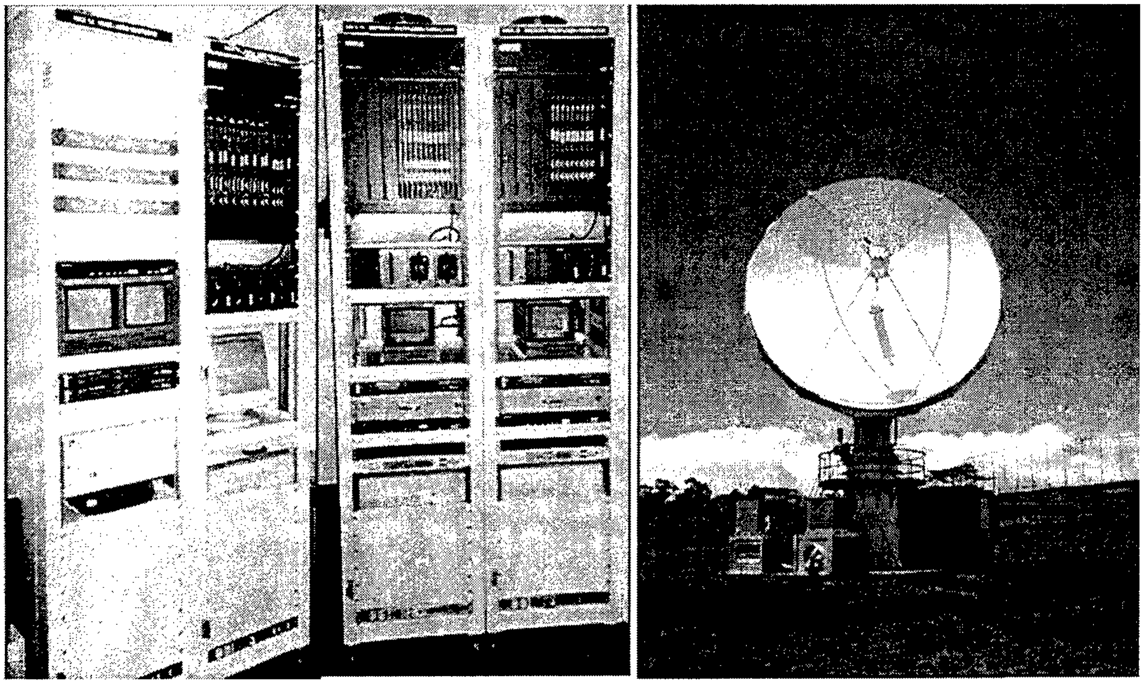

Figure 1. SBM and PIP for UFO 8
[Ref. 8]

On the Phase Two UFO satellites, the GBS payload consists of four transponders, two uplink antennas (one fixed which is pointed at the PIP and one steerable) and three steerable downlink antennas (two spot and one broad area coverage) (Figure 2). Each transponder can be connected to either uplink antenna. However, for downlink, two transponders are connected to one spot beam antenna. The third transponder is connected to the other spot beam; and the final transponder can be switched between the second spot beam antenna and the broad area coverage beam antenna. The downlink antennas can be moved or pointed within the satellite's field of view (FOV) in order to deliver to the optimal broadcast area based on users' needs (CINC approval is required). The changing of the downlink antenna pointing direction may take up to 10 minutes to complete. [Ref. 7]

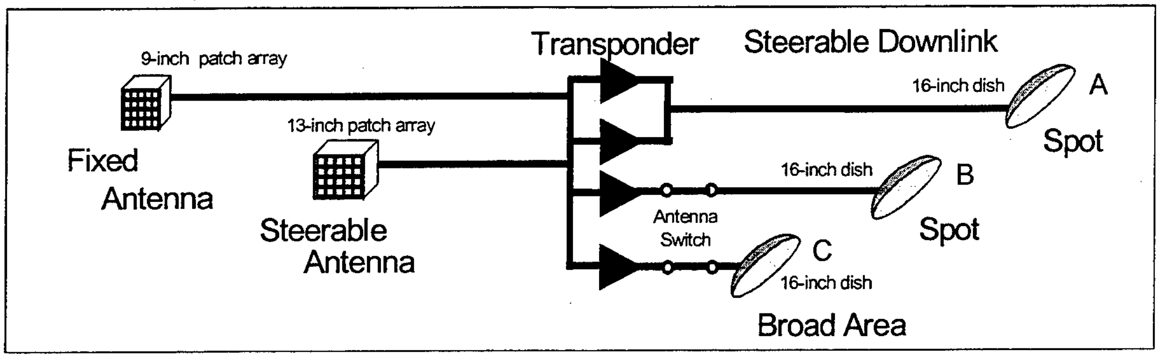


Figure 2. UFO-Hosted GBS Payload
[Ref. 7]

There are various combinations of spot beams (550 nm in diameter of the AOR) and broad area coverage (2000 nm in diameter of the AOR); one option is shown in Figure 3. Theater injection points (TIP) give greater flexibility in meeting users' needs. The TIP injects a 24 Mbps broadcast signal into the steerable uplink antenna. The same 500 nm spot beam area could receive both the TIP and PIP broadcasts. The idea behind a TIP is that the warriors within the theater best understand the information needs within that theater. The reconfiguration of the transponders to uplink and downlink antenna resources is outside the direct control of the SBM and can take hours to days depending on the availability of satellite Telemetry, Tracking, and Control (TT&C) assets.

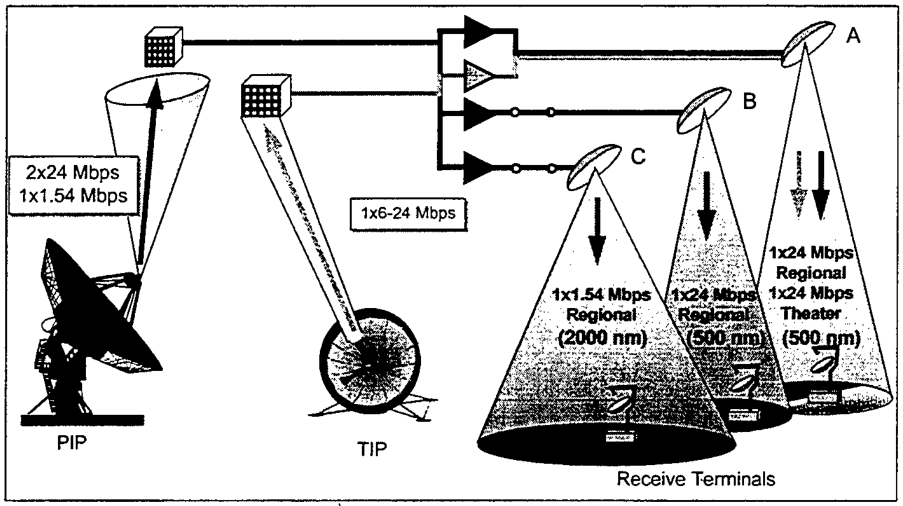


Figure 3. Default UFO-8 Payload Configuration
[Ref. 6]

The receive suite is made up of the receive terminal and the Receive Broadcast Manager (RBM) hardware and software, and the interface. The receive terminal consists of a satellite-tracking receive antenna one meter in diameter and a Low Noise Buffer (LNB). The receive terminals are small, mobile, and receive high-volume data allowing deployed forces to receive data formerly available only to command centers. The RBM consists of a microcomputer, monitor, IRD, Uninterruptible Power Supply (UPS), and KG-75 Fastlane cryptographic equipment. Receive suites can be fixed, transportable, ship-mounted or subsurface mounted during Phase 2. A shipboard receive suite is shown in Figure 4. [Ref. 6]

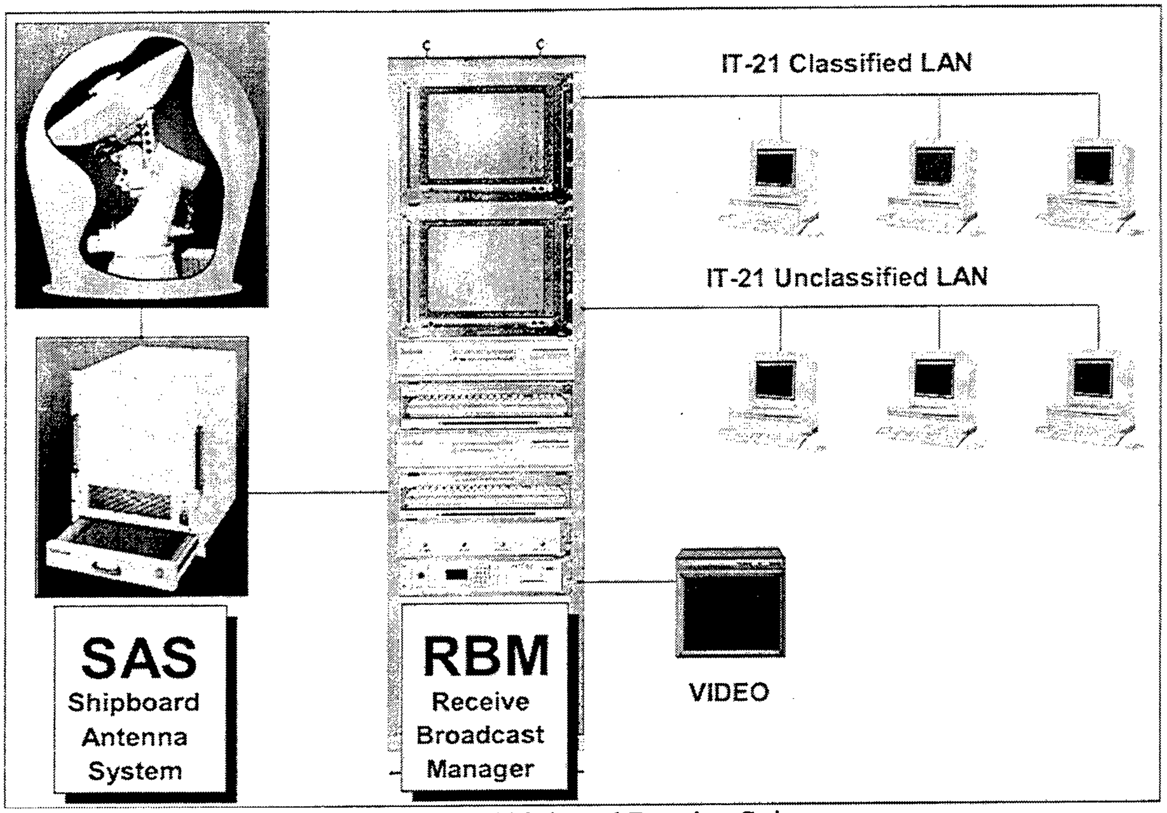


Figure 4. Shipboard Receive Suite
[Ref. 9]

"The TIP will provide in-theater information producers a path for video and data dissemination to in-theater warfighters by developing, building, and injecting theater-produces information directly to the satellite for broadcast to forces within a GBS coverage area." [Ref. 10] Use of the TIP is coordinated with the SBM and approved by the Theater Information Manager (TIM) of the responsible CINC. The TIP consists of a Theater Satellite Broadcast Manager (TSBM) and a Transportable Theater Injector (TTI). The TIP is built so it can be mounted on two High Mobility Multi-Purpose Wheeled Vehicles (HMMWV). The TSBM assembles the data stream, based on resource allocations and information priorities, and forwards the stream to the TTI uplink. The TTI will have the capability to operate in both the Ka-band and Ku-band using a single

antenna but not both bands simultaneously. In Phase Two of GBS, three TIPs are scheduled to be fielded to the Army; however, the Navy has no requirement for direct theater injection onboard ships. For the Navy, in-theater source information is transmitted to the broadcast segment via other communications resources then transmitted to the SBM. Table 2 shows Theater Information Products and their potential users. [Ref. 10]

| THEATER INFORMATION PRODUCTS | POTENTIAL USERS |
|---|---|
| Unmanned aerial vehicle (UAV) video | Amphibious Ready Group |
| Air Tasking Order (ATO) | F-15 Squadron, Air Wing |
| Enemy order of battle | Corps G2 |
| Imagery | Tomahawk Strike Planner |
| Weather reports, Oceanographic Data, METOC | Carrier Battle Group |
| Common Operational Picture (COP) | All users |
| Operational Graphics | Armor Brigade |
| Battle Damage Assessment | Air Component Commander |
| Theater Missile Defense Warning | Theater rear area |
| Daily Operations/Intelligence Briefs | Carrier Battle Group |
| Logistics | All users |

Table 2. Example of In-theater Information Products [Ref. 10]

## C. THE THREE PHASES OF GBS

### 1. Phase One

Phase One is short term from 1996 to 1999 using commercial satellite services operating at Ku-band. The objectives of Phase One are to operate the Joint Broadcast Service (JBS), limited off-the-shelf capability, determine products and applications that

best suit the CINC and Joint Task Force (JTF), develop information management software, further refine the Concept of Operations (CONOPS), develop in-theater capability, and initiate connectivity from information producers to GBS. JBS is part of the Bosnia Command and Control Augmentation (BC2A) Initiative, which is a Secretary of Defense sponsored program to improve information delivery to forces supporting the North Atlantic Treaty Organization (NATO) operation in Bosnia. JBS and BC2A lessons learned will improve future GBS phases. [Ref. 7]

### 2. Phase Two

Phase Two is mid term in the program from 1998 to 2009 and beyond. Payload packages are hosted on UHF Follow-On (UFO) satellites 8, 9, and 10 with downlink broadcast operating at 20.2-21.2 GHz (Ka-band). The objectives of Phase Two are to launch UFO 8, 9, and 10; lease commercial satellite services over CONUS; acquire receive suites, information management software and broadcast management systems; continue to develop GBS hardware and software products; integrate GBS with MILSATCOM architecture and the DII; complete connectivity; and develop tools necessary to employ GBS with user systems (e.g., Global Command and Control System (GCCS)). [Ref. 7]

UFO 8, which became operational in March 1998, is in geosynchronous orbit at 172° East longitude and provides coverage of the Pacific Ocean and most of its surrounding land masses. [Ref. 6] The SBM/PIP for UFO 8 are located at NCTAMS Pacific in Wahiawa, Hawaii.

UFO 9, which became operational in October 1998, will provide GBS coverage primarily in the Atlantic AOR. NCTAMS Atlantic in Norfolk, Virginia is the SBM/PIP for UFO 9.

UFO 10 is scheduled for launch in the last quarter of 1999. [Ref. 11] UFO 10 will provide coverage to EUCOM, PACOM users in the Indian Ocean, Australia, portions of eastern Asia and the western Pacific. [Ref. 6] NCTS Sicily, located on NAS Sigonella, Italy is the SBM/PIP for UFO 10. Figure 5. shows the coverage areas for UFO 8, 9, and 10 during GBS Phase Two.

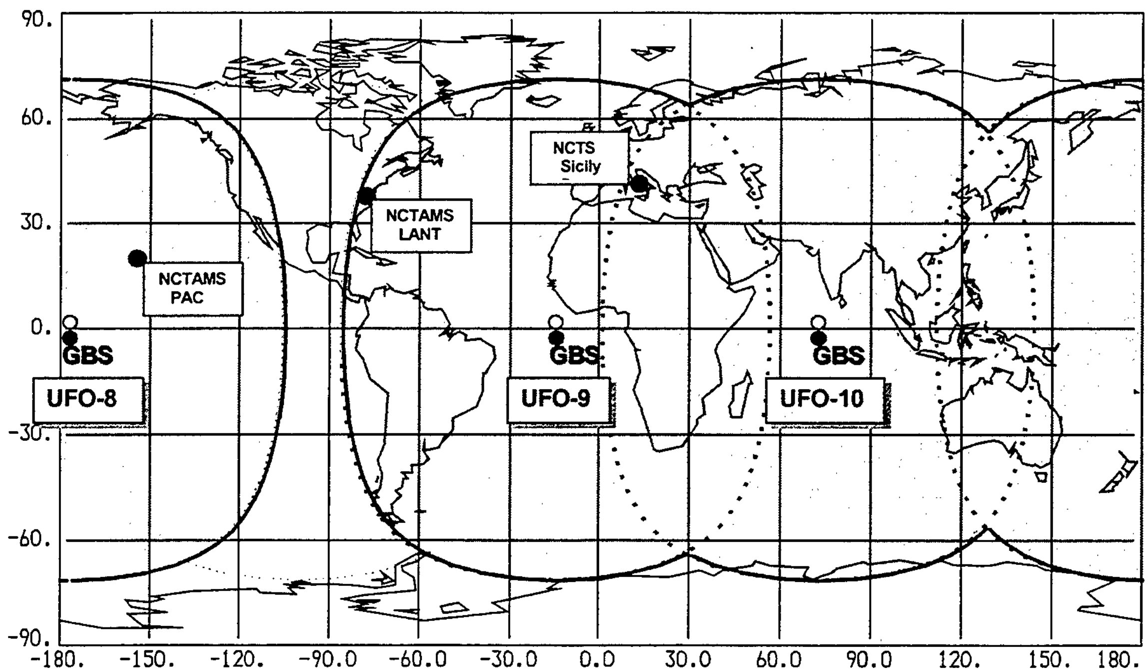


Figure 5. Coverage Areas for Phase II
[Ref. 7]

### 3. Phase Three

Phase Three is long term from 2009 and beyond. The objectives of Phase Three are to achieve objective capability, complete acquisition of space, ground, and user

segments, and complete the integration with GCCS and other theater information management systems. Phase Three will include “Full earth coverage” from 90° North to 65° South latitude and 180° West to 180° East longitude. This coverage will be provided by five satellites, each having twelve transponders and seven spot beam antennas transmitting at data rates greater than 6 Mbps. Additionally, there will be ground mobile receive suites capable of receiving and processing the GBS downlink while on the move, manpackable receive suites suitable for special operations, and airborne receive suites capable of receiving the GBS broadcast in all flight configurations and attitudes. [Ref. 6]

# III. GBS REACH BACK

## A. BACKGROUND

GBS is an *asymmetric* system that provides large bandwidth from the SBM to operating forces, but *not* a return path via GBS back to the SBM. Due to the lack of a return path or reach back channel via GBS, users are limited by the lack of an effective way to request the broadcast of information specific to their immediate operational needs. This limitation is due, in part, to receive terminal equipment configurations which do not incorporate upconverters, power amplifiers and other components needed for transmitting. This limitation is made worse by the technical performance of the receive antenna, whose wide beamwidth can illuminate multiple, closely spaced geosynchronous satellites resulting in interference to other satellite users. [Ref. 12]

The GBS MNS points out that the ability of users to tailor the broadcast to satisfy emergent requirements is a primary feature of GBS. Users tailor the broadcast through the concept of User Pull. The GBS ORD states that in order to accommodate User Pull, users will request information through *existing* information retrieval paths. [Ref. 13] The concept of User Pull works hand in hand with Smart Push.

Smart Push is the process by which information is routinely and continuously broadcast by the SBM based on known requirements of users and user groups without responding to individual or specific requests. This Smart Push information is placed on a broadcast on a prearranged schedule or as updated information becomes available. The TIM will accommodate user needs to the maximum extent possible while matching

available resources with demand. The TIM also takes into account the established CINC and CJTF priorities. The primary goal of Smart Push is to give users within the CINC's AOR the majority of their predictable information needs. [Ref. 6]

User Pull is requests by the user for information from both inside and outside the theater. This class of service will help satisfy access to remaining information needs that are not met through Smart Push. Examples of information that would be requested through User Pull include tailored intelligence data, imagery, imagery perspective products, battle damage assessments (BDA), Tomahawk Mission Data Updates (MDU), local weather forecasts, regional or local environmental updates, high-speed computer updates, news updates, and mapping, charting and geodesy (MC&G) products. [Ref. 2]

Possible examples of existing architecture for User Pull include Joint Deployable Intelligence Support System (JDISS) or INTELINK, Internet or DII router networks (e.g., Secure Internet Protocol Router Network (SIPRNET), JWICS), GCCS, Defense Message System (DMS), telephone (secure or non-secure), cellular phone, satellite mobile phone, commercially available very small aperture satellite terminals (VSAT), UHF SATCOM, Super-High Frequency (SHF) SATCOM, and EHF SATCOM. The different modes for GBS reach back are described in Appendix A.

As mentioned earlier, USPACOM is prototyping GBS. The PACOM standard for the satisfaction of User Pull subscriptions for products listed in the GBS Product Catalog is that they will occur immediately if the product is already part of the Program Guide. One to two hours will be required for the SBM to retrieve the requested products and

insert them into the broadcast queue if they are not available in the GBS Product Catalog. [Ref. 14]

On the other hand, the total time to incorporate GBS Product Requests for *new* products into the GBS Broadcast varies from days to months depending on technical and fiscal constraints. Technical constraints involve integrating the new product from the information provider or source with the SBM's retrieval and transmission architecture. Fiscal constraints involve funding to support the communications connectivity required between an information provider and the SBM facility. [Ref. 14]

To clarify how the information management side of the prototype of GBS is being handled, Commander-In-Chief, United States Pacific Command (USCINCPAC) is responsible for providing operational guidance and direction for the use of GBS in USPACOM. USCINCPAC performs this role through the formation of the GBS Information Management Board (GIMB), co-chaired by the J2 and J3, and composed of members from the six Headquarters directorates. Membership from the Headquarters directorates ensures each directorate's functional area is represented in advocating users' requirements, resolving cross-functional issues, and determining Smart Push information products. This ensures balanced and optimal use of GBS. Additionally, J6 is responsible for the oversight and management of GBS fielding and operations in USPACOM. [Ref. 14]

USCINCPAC fulfills the role of the lead TIM for UFO 8 through the GIMB. GBS TIMs from *other* CINCs, services, and agencies coordinate with the USCINCPAC GIMB to request UFO 8 GBS resources and/or the broadcast of new information products

to users within the UFO 8 FOV using the "GBS Product Request Form" shown in Appendix B. [Ref. 14]

Program guides produced by the SBM facilitate the warfighters' use of GBS. Figure 6 shows a sample PACOM program guide.

| Time / *Channel* | 1300 | 1400 | 1500 | 1600 | 1700 | 1800 | 1900 | 2000 | 2100 | 2200 |
|---|---|---|---|---|---|---|---|---|---|---|
| Channel 1 | Constant news broadcasts (e.g., CNN) | | | | | | | | | |
| Channel 2 (Video) | Wx | Intel | Cmd Info | J2 Challenges Briefing | | Wx | Medical Training & Medical Intelligence | | | |
| Channel 3 | Smart Push Data | | | | | | | | | |
| Channel 4 | User Pull Data | | | | | | | | | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| ATO | Map | Image | Intel | Wx | Software Update | Map | Map | Image | Image |

Figure 6. Sample Broadcast Schedule
[Ref. 6]

The GBS Product Catalog lists approved data products that are available or accessible to the SBM for broadcast. Associated with the Product Catalog is the GBS Program Guide, which lists data products currently in the broadcast queue. Products are broadcast in a 'round robin' manner; the cycle time for the broadcast is dependent upon the total size of all products in the broadcast queue. The SBM adds or removes products from the Program Guide based on:

- Catalog subscriptions received from the end users (User Pull)
- Direction from USCINCPAC J6 and/or the GBS SBM Officer (Smart Push)

- "Timeframe when Products are Required" information taken from the GBS Product Request Form that led to the product being added to the catalog (Smart Push)
- Requests submitted by information providers, headquarters staffs, and operations planners via the SBM's GBS Channel Builder Homepage (Smart Push). Based on USCINCPAC J6 validation, the SBM grants users access to this home page. [Ref. 14]

The GBS Product Catalog and Program Guide are disseminated continuously by the SBM via the GBS broadcast, and are available to end users via their respective GBS receive suites. They are also available on the USCINCPAC J6 SIPRNET web page: [http://www.hq.pacom.smil.mil/j6/j63/gbs/gbspage1.htm]. Video program information is transmitted separately via broadcast order wire, and posted on the J6 SIPRNET web page. [Ref. 14] *End users need to subscribe to GBS data products in order to receive them.* Subscriptions to GBS data occur as follows:

Product Catalog subscriptions: Using a web browser from their workstations, end users access the Product Catalog on their GBS receive suite, and subscribe to desired data products. After making the subscription on the receive suite, end users must also coordinate with the SBM Help Desk via telephone, electronic mail, facsimile, or message. (The system is not fully automated yet.) After receiving the requested product, the SBM adds it to the Product Guide for subsequent broadcast. [Ref. 14]

Program Guide subscriptions: Using a web browser from their workstations, end users access the Program Guide on their receive suite, and subscribe to desired

information products. Previous subscriptions will already be available on the receive suite. New subscriptions will be available after they are broadcast by the SBM and downloaded by the receive suite. [Ref. 14]

## B. REACH BACK EXPERIMENTS

### 1. JWID 1996

During Joint Warrior Interoperability Demonstration (JWID) 1996, the Army sponsored a GBS reach back demonstration using the EHF MILSTAR SATCOM system. A dedicated 2400 bps point-to-point link between remote users and the JTF Headquarters was provided by the MILSTAR System. The demonstration was hosted onboard the USS KEARSARGE, and at Fort Bragg, North Carolina. The operators communicated directly with information providers via the SIPRNET; the requested information was wrapped and delivered via the SIPRNET to the GBS uplink facility. With some exceptions taking up to 15 minutes, the request-to-receipt cycle time was typically three to five minutes. The exceptionally long delivery times were attributed to the GBS broadcast queue length and poor weather conditions at the uplink facility which disrupted the uplink signal. [Ref. 15]

### 2. JWID 1997

In 1996 Naval Research Lab (NRL) demonstrated to National Reconnaissance Office (NRO) Operational Support Office (OSO) the ability to use available bandwidth within the GBS Phase I transponder to support bi-directional capability. Simultaneous occupation of the reach back and broadcast signal did not adversely affect the GBS signal.

As a result, the OSO used this single transponder-back channel capability to demonstrate actual "User Pull" over the same GBS transponder using information requests via an email type interface during JWID 97. The reach back channel operated at 40 Kbps and used Direct Sequence Spread Spectrum (DSSS) to prevent interference to adjacent satellites. A 1.2m VSAT transmitted the reach back signal. The software at the SBM processed the request, then placed the requested file onto the broadcast manager's queue. Request-to-receipt cycle time took less than five minutes with some exceptions taking up to 40 minutes. As in JWID 96, broadcast queue delays probably contributed to the longer delivery times. The JWID 97 reach back capability was limited in that it used proprietary software implementing a partially connected (email request) GBS mode. Additionally, it only implemented a single back-channel, was limited in its ability to scale to multiple users, and was not portable to GBS Phase II. [Ref. 16] With only two receive antennas (one steerable), the GBS Phase II system does not support user reach back via the same satellite. The receive antennas are used solely for broadcast signal injections from one PIP and multiple TIPs (if within 350nm of each other). [Ref. 15]

### 3. JWID 1998 and Urban Warrior

NRL and OSO worked together to demonstrate the use of standards-based commercial network protocols to implement a real-time User-Pull/Smart-Push GBS Phase I and II capability during JWID 98 and Urban Warrior. Using GBS as the communications path to the warfighter, a network was designed to support commercial-off-the-shelf (COTS) and government-off-the-shelf (GOTS) TCP/IP applications to

provide real-time bi-directional capability to the warfighter. The COTS applications included Email (SMTP), FTP, TELNET, WWW browsing, multicast, reliable multicast, MS NetMeeting, and database access as well as GOTS applications like GCCS, Common Operational Modeling, Planning, and Simulation Strategy (COMPASS), and Joint Computer-Aided Acquisition and Logistic Support (JCALS). Using these fully connected networked capabilities allowed warfighters who can not support large antenna structures to interface with terrestrial networks (SIPRNET, NIPRNET, Coalition Wide Area Network (CWAN)) in a seamless manner. The location of the different reach back channels and the reach back channels included:

- HMMWV at Fort Gordon - cellular phone, SINGARS
- JBC - DSSS in-band transmission, telephone service (POTS)
- Virtual Ship at SPAWAR Charleston – Automated Digital Network System (ADNS) connectivity including Inmarsat B and UHF DAMA
- HMMWV at Camp Lejuene - UHF MILSATCOM, DSSS in-band transmission, and cellular phone

All the sites operated successfully and demonstrated asymmetric network connectivity and supported TCP/IP network applications. The sites shared the broadcast channel with little measurable impact. [Ref. 16]

### 4. Naval Postgraduate School Research

#### *a. UHF-DAMA*

A Naval Postgraduate School (NPS) master's thesis recognized that UHF-DAMA satellite communications are the most widely available long haul communication systems available to DoD, which makes it an ideal reach back option for GBS. Through the use of point-to-point tunneling protocol (PPTP) to deal with the long latency of UHF DAMA, an email message was sent over UHF-DAMA to request information be scheduled for broadcast over GBS. This experiment showed that UHF DAMA is a viable reach back option for GBS, however, the long latency of UHF DAMA is still an issue if using TCP/IP communications. [Ref. 15]

#### *b. Extend™*

An NPS master's thesis developed a GBS model using Extend software as a tool to analyze information dissemination management (IDM). Extend is a modeling program developed by *Imagine That! Incorporated.* A simulation using Extend provided an analysis of various reach back channels; asymmetric networking and automated radio frequency management are part of the model. The use of Smart Pull (instead of Smart Push/User Pull) by the user was advocated. UHF-DAMA received high marks as a reach back channel due to its coverage and accessibility. [Ref. 17]

DISA is fielding "Little IDM" software June 1999 through January 2000 to support the Smart Push/User Pull concept on GBS. The Joint Battle Center (JBC) started conducting an assessment of the IDM Software, Release 2, in June 1999. These bundles

of software mark a sizeable increase in capability for CINC TIMs and SBMs to provide the right information to the warfighter. The software is a blend of COTS, GOTS and transitioned Advanced Concept Technology Demonstration (ACTD) products that will improve over time as DoD moves forward to metadata standards and COTS improvements. [Ref. 18]

## C. ONGOING/FUTURE RESEARCH AND EXPERIMENTS

### 1. MINER™ Information Management Toolkit Testing

GBS Increment One Enhanced (GBS I1E) Performance Test from 19-30 June 1999 onboard the USS CORONADO using the Managed Information & Network Exchange Router (MINER™) Information Management Toolkit has shown positive results. MINER™, which was developed by General Dynamic Information Systems (GDIS), " is a content aware information router that manages local network resources and coordinates with other Information Management (IM) enabled services to provide managed access to information at deployed and mobile sites." [Ref. 19]

The GBS Common Operational Picture (COP) Replication Channel (COPRC) is an immediate dissemination channel that allows data to flow over GBS in near real-time instead of waiting for a scheduled broadcast. Although the COPRC was designed to provide GBS with the capability to satisfy a specific mission need for COP data dissemination to GCCS, MINER has demonstrated that the COPRC has general-purpose near real-time (seconds to minutes) data dissemination utility. MINER has used the COPRC to give GBS an immediate, DirecPC-like capability for User-Pull. When fully

developed, the added value of MINER's end-to-end content-aware information management capabilities will provide a "clip-on" that can be provided to GBS users who have sufficient reach back connectivity. [Ref. 20]

As an example of MINER's capability, during the testing aboard USS CORONADO, test personnel profiled for a video clip, attendant thumbnail file and 4 web pages, all over GBS COPRC. The video clip was delivered within 4 minutes end-to-end and the web pages were delivered within 2 minutes. [Ref. 20]

### 2. Asymmetric Networking

Another area of research is asymmetric networking which can be defined as a network with different physical capabilities in the forward and return directions. An example is a high capacity satellite downlink connected to a low data rate terrestrial network. The satellite downlink is used to receive data only; the terrestrial network is used to send data. GBS is an asymmetric network which provides a one-way channel from the SBM/PIP at the NCTAMS to the RBM that transports up to 24 Mbps of data or video. A return channel from the RBM to the SBM/PIP was not designed as part of the system; an existing system will be used for the return path. The physical asymmetry creates problems for TCP.

Asymmetric networking using GBS will provide bi-directional network connectivity; which means real-time WWW access to any WWW SIPRNET server, if the SIPRNET is the reach back channel used. Bi-directional network connectivity would result in reduced information management requirements, automatic acknowledge of data

receipt, assured data delivery, greatly increased Smart Push/User Pull capability and more efficient use of bandwidth. Asymmetric networking using GBS and varying reach back channels was the focus of JWID 1998. [Ref. 21] NRL has proposed a four tiered approach to implementing asymmetric networking on UFO 8. [Ref. 22]

The JBC conducted a survey of all the CINCs to build their GBS FY 00 plan. This survey identified asymmetric networking as a required capability to support GBS operations in PACOM. Collaborative efforts between JBC, NRL, DISA and GBS JPO are underway and will lay the ground work for evaluation of asymmetric networking in FY00. [Ref. 18]

### 3. Spaceway™

As mentioned earlier, working to improve the concept of DirecPC, Hughes Network Systems, in an alliance with AOL, is developing Spaceway. Using a globally deployed system of satellites in conjunction with a ground-based infrastructure, users will transmit and receive video, audio, multimedia and other digital data hundreds of times faster than over conventional phone lines with uplink rates between 16Kbps to 6Mbps. Access to the system is through the user's 26-inch terminal. [Ref. 23]

Operating in the Ka-band spectrum, Spaceway will consist of interconnected regional satellite systems providing service to nearly all of the world's population. The first regional system in North America will offer service as early as 2002. The initial North American constellation will consist of two Hughes-built HS 702 geosynchronous satellites, plus an in-orbit spare. The system will employ innovative on-board digital

processors, packet switching and spot beam technology to offer point-to-point (or full-mesh) communications, which will offer direct connectivity without routing through a hub, as well as broadcast capability throughout the service area. [Ref. 23]

## D. EXPECTED BENEFITS OF THIS THESIS

The expected benefits of this thesis is to provide an update on GBS and reach back options. The experiment setup will allow for the review of another reach back option through S-TADIL J. Although this reach back method would start out in the manually connected mode, the possibility exists for it to become fully connected.

# IV. SATELLITE TACTICAL DIGITAL LINK J (S-TADIL J)

## A. LINK 16

Link 16 grew out of a Joint Service operational requirement from Southeast Asia. The Joint Chiefs of Staff (JCS) Memorandum SM-205-71 established the Ground and Amphibious Military Operations (GAMO) program to ensure compatibility, interoperability, and operational effectiveness of tactical command and control operational facilities and systems used in support of ground and amphibious military operations. Later, GAMO was replaced by the Joint Interoperability of Tactical Command and Control Systems (JINTACCS) program. The purpose of Link 16 is the exchange of real-time tactical data among units of the same force. Tactical Digital Information Link (TADIL) TADIL J is the term used by the U.S. joint services. NATO forces and the U.S. Navy use the term Link 16; TADIL J is synonymous with Link 16. [Ref. 24] The link protocols used in Link 16 were developed before the Internet and TCP/IP were standardized and in popular use. As a result, Link 16 does not use TCP/IP and is completely separate from the Internet.

In comparison to other links, Link 16 offers improved situational awareness, weapons coordination, communications, navigation, identification, data accuracy and capacity, availability, and number of participants as well jam resistance, nodelessness, and secure voice. [Ref. 25]

The major components of the shipboard Links 16 system include the Tactical Data System (TDS), Command and Control Processor (C2P), and the Joint Tactical

Distribution System (JTIDS). The TDS and C2P provide the tactical data that is exchanged. The C2P translates between the normalized data provided by the TDS and the appropriate message series for each link.

The TDS consists of one or more AN/UYK-43 computers; its major functions are providing tactical digital information to data link participants, receiving and processing incoming tactical digital information from other link participants, and maintaining the tactical data base. [Ref. 25]

JTIDS is the communications component of Link 16. The JTIDS program was established as a Joint Service program to develop and acquire a secure, jam-resistant communications system with inherent capabilities to support information distribution, relative navigation, and identification among and within the services tactical command and control facilities and systems. JTIDS, designated the AN/URC-107(V)7, includes the Class 2 terminal software, hardware, RF equipment, and the high capacity, secure, antijam waveform it generates.

The JTIDS shipboard configuration is composed of the AN/URC-107(V)7 Class 2H Radio Set Terminal, Notch Filter Assembly, and antennas. The AN/URC-107(V)7 employs spread-spectrum communications techniques to perform communications, navigation and identification functions. The AN/URC-107 Class 2 Terminal is locally managed electronic cabinet assembly (ECA) that houses the following Weapons Replaceable Assemblies (WRAs): Receiver/Transmitter (RT), Indicator Control (IC), High Power Amplifier Group (HPAG), Data Processor Group (DPG), Keyer Control

Panel (KCP), battery, Power Interface Unit (PIU), and Secure Data Unit (SDU). The Notch Filter Assembly is outside the ECA. [Ref. 26]

The RT provides Radio Frequency (RF) and Intermediate Frequency (IF) signal processing for transmit and receive functions. The IC (1) provides the interface between the operator/technician and the terminal, (2) permits the application of power, and (3) allows monitoring of the WRA status. The HPAG consists of the HPA and the AIU. The DPG consists of two major subcomponents which are the Interface Unit (IU) and Digital Data Processor (DDP). The IU provides discrete signal, voice/data, and control and management function interface requirements between the terminal and the host. The DDP performs real time control of the RT, HPAG, and message transmission and reception and encodes and decodes messages. The KCP is used to initialize the radio set and provides the capability for long loading crypto variables into the SDU. The Notch Filter provides additional IFF interference protection. [Ref. 26] JTIDS operates in the 916-1215 MHz frequency band and employs Time Division Multiple Access (TDMA) architecture. [Ref. 25]

Multifunctional Information Distribution System (MIDS) is the future communications component of Link 16 and offers the same capabilities as JTIDS in a smaller, lighter package. MIDS, designated the AN/USQ-140(V), will replace JTIDS in all ships beginning in FY 05 and will be installed in all new construction ships beginning in FY 03. [Ref. 27] Neither JTIDS nor MIDS appears to have a Simple Network Management Protocol (SNMP) agent.

## B. COMMAND AND CONTROL PROCESSOR (C2P)

The C2P is a TADIL control system; it provides for real-time control and management of the TADILs to support all major surface ship Command and Control (C2) systems. C2P is a subsystem of the ship's combat system and automates link protocol, message formatting, connectivity maintenance, and message receipt/compliance functions. C2P has a data forwarding capability to permit inter-communications connectivity between Link-11 and Link-16; however, it does not have an IP router interface nor ATM interface. All JTIDS-equipped surface platforms are equipped with a C2P. [Ref. 27]

C2P controls the Link-16 Radio Set operation. C2P system functions include data forwarding with control from CDC/CIC via C2P Display Terminal, filtering of data per filter order received from host systems, link performance monitoring and alerting Combat Direction System (CDS) to link outages, performing all message formatting, framing, and timing. The C2P subsystem (AN/UYQ-62(V)) includes the AN/UYK-43A(V) Computer Set with Embedded Memory Subsystem (EMS), and the AN/USQ-69(V) Data Terminal Set (DTS) shown in Figure 7. The AN/USQ-69(V) DTS serves as the Human-Machine Interface (HMI) between the C2P Subsystem and the Link-16 Radio Set. The C2P subsystem can also use the AN/UYK-43C(V) Lowboy Computer Set with an AN/UYH-16 Hard Drive (External). The AN/UYQ(V) relationship to Link-16 is that it controls the URC-107(V)7 Radio Set initialization, operation, and link participation, acts as a translator between the CDS and link data, and acts as a translator/data forwarder between Link-11 and Link-16. The AN/USQ-69 DTS provides the means to prepare, display, edit,

and transmit text messages to the UYK-43, displays output from the UYK-43, and is the HMI for the Link-16 Radio Set via the UYK-43. [Ref. 26]

C2P Rehost, C2P(R), is the implementation of C2P functions within VME cards housed in an AN/UYQ-70 cabinet. C2P(R) installations began in FY 98; C2P(R) will be back-fitted on Link 16 surface platforms to replace the UYK-43 based C2P's. [Ref. 27]

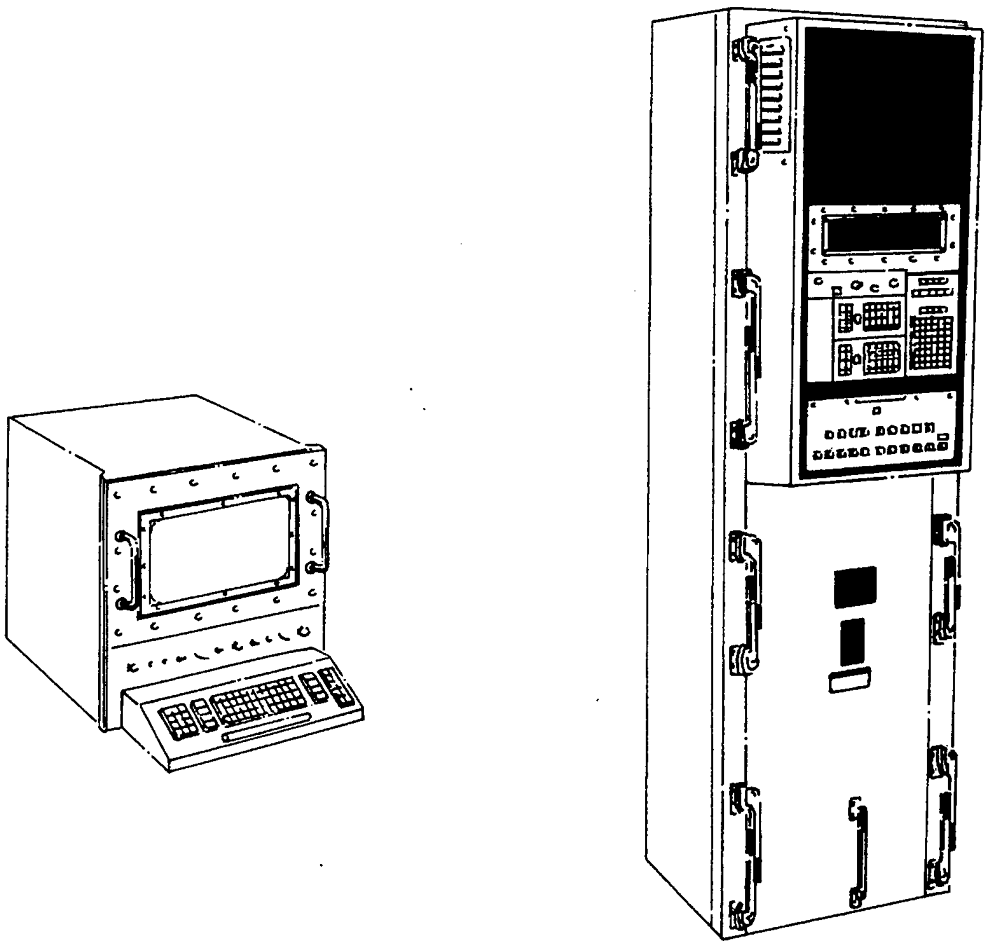

Figure 7. DTS USQ-69 (left) and C2P UYK-43 (right)
[Ref. 26]

## C. S-TADIL J

The Joint Range Extension (JRE) program is the extension of Link 16 Beyond Line of Sight (BLOS) using satellite communications (example shown in Figure 8) and within the Navy is called S-TADIL J for Satellite TADIL J. [Ref. 28] The Navy has a requirement for S-TADIL J when airborne relay is not available to C2P equipped surface units or when C2P equipped surface units are beyond JTIDS range. Engineering Change Proposal 173 (ECP-173) required that the S-TADIL J network be designed and implemented on the C2P. The S-TADIL J interface design supplements JTIDS/Link 16 and MIDS range extension when tactical units (i.e., USN ships) are widely dispersed BLOS JTIDS connectivity. MIDS is the NATO equivalent of JTIDS. Initial development of S-TADIL J began in January 1995. [Ref. 29]

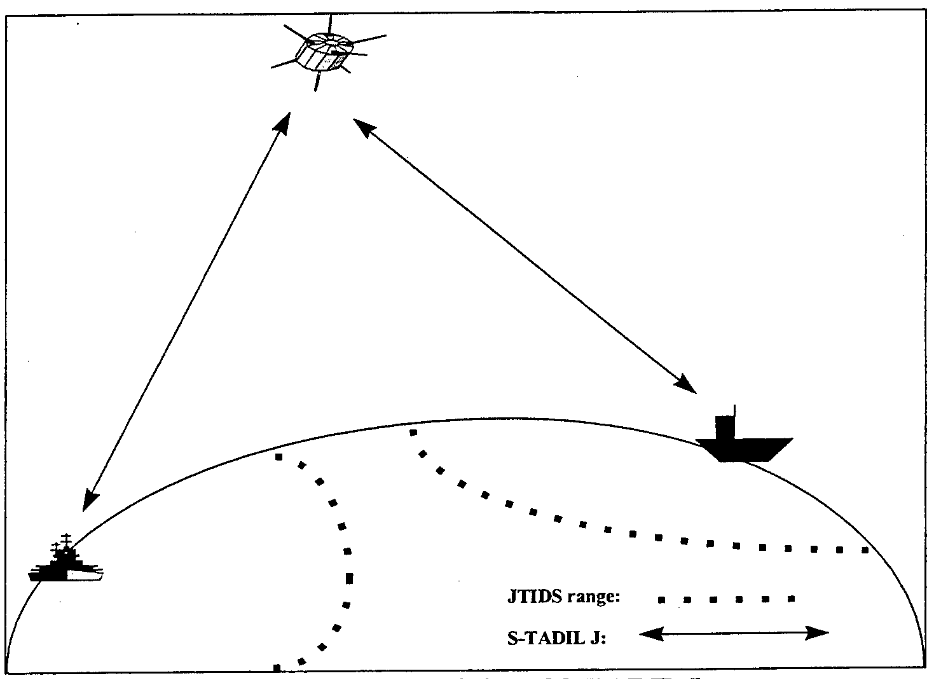


Figure 8. BLOS Connectivity of S-TADIL J
[Ref. 29]

In November 1996, USS CARL VINSON (CVN-70) demonstrated two-way real-time satellite TADIL connectivity between S-TADIL J equipped platforms over extended distances. [Ref. 30] The Commander of Cruiser Destroyer Group Three had the following to say about S-TADIL J:

> The C2P combined with S-TADIL J effectively eliminates medium- and long-range connectivity holes, gaps, and propagation limits of traditional TADILs. This TG was provided with an unprecedented degree of TADIL connectivity resulting in a consistent tactical picture throughout the Force, greatly enhancing situational awareness. Continuous and robust link connectivity greatly decreased workload associated with tactical situation display management and maintenance on all platforms. Recommend S-TADIL J capability be added to operational C2P software immediately and provided to all TGs. [Ref. 30]

The S-TADIL J concept provides a satellite communication network to exchange J-Series messages via UHF DAMA or UHF Non-DAMA satellite communication channels. S-TADIL J supports the full two-way exchange of Link 16 over 25 KHz DAMA UHF channels. [Ref. 27] Beyond J-Series messages, S-TADIL J and JTIDS share no common physical equipment. S-TADIL J uses standard U.S. Navy shipboard satellite communications equipment and is currently implemented on Navy DAMA satellite communications channels. C2P also incorporates Non-DAMA UHF satellite communications capability in the current design as a backup mode of operation to handle high track load environments and to support future expansion onto other satellite media.

The S-TADIL J network was designed to complement the TADIL J link being used across the Joint and NATO tactical arenas. At the time of ECP-173's conception, no real-time tactical data exchange satellite protocol was available. S-TADIL J network requirements include:

- Maximum time between data element (track) updates shall not exceed 20 seconds.
- Total data latency shall not exceed 12 seconds, and shall be removed by track extrapolation.
- Network time reference accuracy better than 100 ms between all users.
- Support Navy Battle Groups within UHF DAMA equipment limitations.
- Non-satellite specific protocol that is expandable to EHF, SHF and commercial satellite systems.
- Provide common network time structure to allow extrapolation of all data to account for satellite delays and data latency caused by transmission packing, encryption and unpacking. [Ref. 29]

S-TADIL J provides TADIL J message connectivity BLOS, and is range limited only by the satellite footprint. C2P S-TADIL J design uses the concurrent operations software to provide seamless transition between JTIDS path data and S-TADIL J path data as JTIDS connectivity is gained and lost. Concurrent operations mode was designed into the Navy's C2P link architecture prior to S-TADIL J design; C2P S-TADIL J exploits concurrent operations software design to produce the seamless transition between JTIDS and S-TADIL J. S-TADIL J protocol was designed to compliment the seamless transition concept by providing a smooth transition (transparent to the operators) as C2P selects the *best* primary link data source.

S-TADIL J is bandwidth limited with UHF DAMA to 2400 or 4800 bps. This bandwidth limitation results in S-TADIL J not being able to support either JTIDS air control or voice channels. ECP-173 required S-TADIL J to be a ship to ship extension of JTIDS, so air control is not required. JTIDS voice channels use 16,000 bps of bandwidth each, which exceeds DAMA bandwidth. [Ref. 29]

S-TADIL J is a high efficiency token passing protocol for a network of 16 units, designed in growth to support imagery, free text, and TCP/IP data. The C2P concept of operations provides the core of S-TADIL J JRE opportunities as shown in Figure 9. C2P S-TADIL J installations use a C2P UYK-43 to control the network protocol; C2P is the terminal for the S-TADIL J network. Multi-TADIL operations concept allows C2P to seamlessly transition between JTIDS and S-TADIL J. Concurrent Link 16, Link 4A, and Link 11 (dual Link 11) operations with S-TADIL provides Common Surveillance Picture to all C2P links.

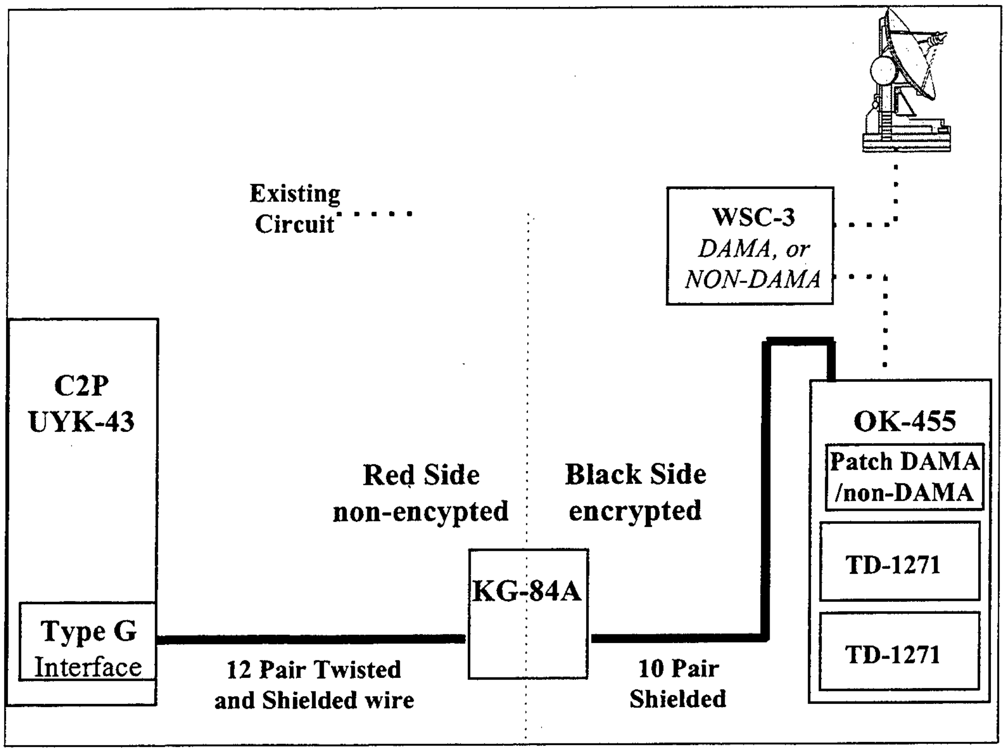


Figure 9. Generic S-TADIL J Installation
[Ref. 29]

The first shipboard installations of S-TADIL J took place in the last part of FY 99 with the STENNIS Battle Group. [Ref. 27] Appendix C lists the dates for subsequent S-TADIL J installations on other surface platforms.

S-TADIL J uses 25 KHz DAMA UHF channels. There are nine UFO satellites in geosynchronous orbits; eight active plus one spare as shown in Figure. 10. With the UFO satellites in geonsynchronous orbit, they provide coverage from 65° North latitude to 65° South latitude leaving the polar regions without coverage. Any units above 65° latitude will not have UHF capability, which is a consideration when using S-TADIL J.

UHF coverage is provided primarily by the UFO satellites, with two satellites per footprint. UFO 8, 9, and 10 also carry GBS payloads. UFO-10 is the last UFO satellite to

be launched. There are 17 25-KHz channels per satellite. Fleet Satellite (FLTSAT), Leased Satellites (LEASAT) and gapfillers also used for UHF will be phased out by attrition. [Ref. 31]

SATCOM including UHF SATCOM are managed resources according the priorities established by the Chairman of the Joint Chiefs of Staff. The Joint Staff J6 is responsible for "ensuring the effective and efficient apportionment, allocation and adjudication of DOD satellite resources." Through the apportionment process blocks of SATCOM resources are assigned to CINCs and other users who then allocate their block to subordinate commands. Apportionment is based on the current operational situation, threat conditions, and operational requirements. [Ref. 32] Multi-service planning and management sites located at NCTAMS in Wahiawa, Hawaii; Norfolk, Virginia; and Naples, Italy support users with their apportioned resources. [Ref. 31]

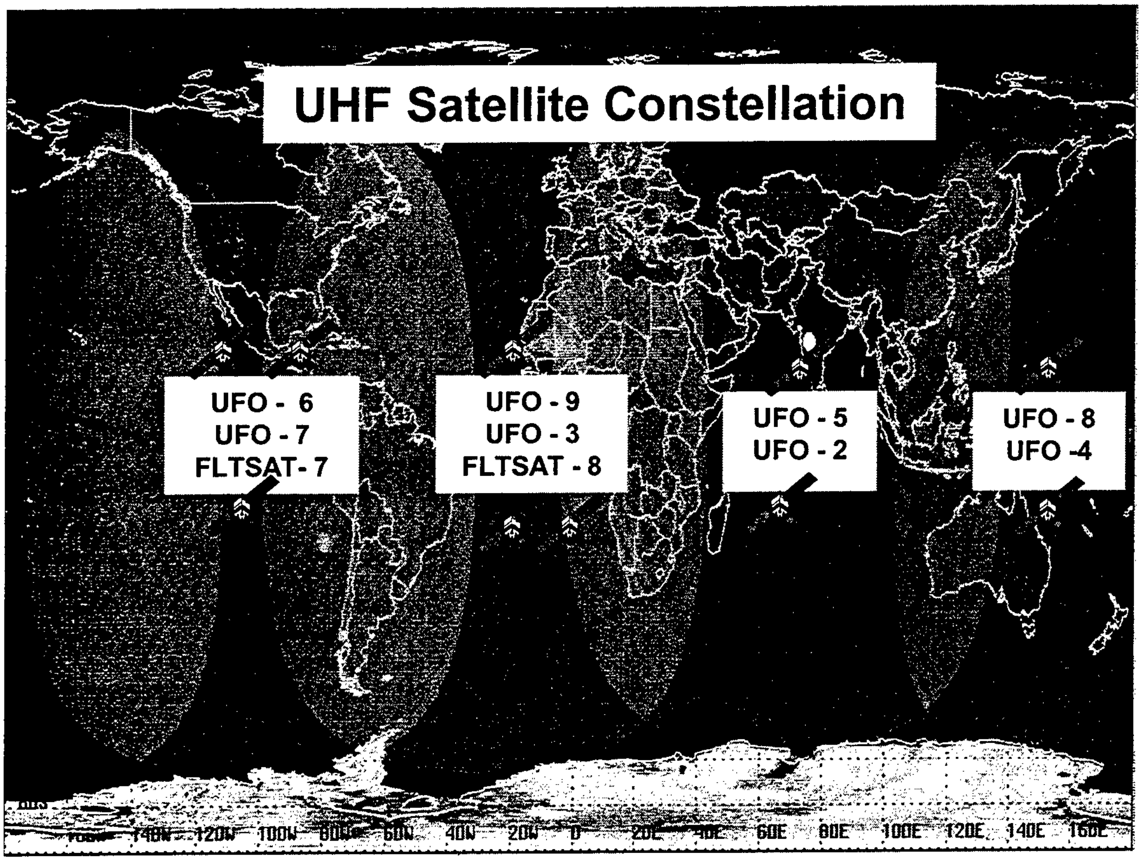


Figure 10. UHF Satellite Constellation

# V. EXPERIMENT SETUP

## A. BACKGROUND

In order to determine whether S-TADIL J is a viable reach back option for GBS, an experiment between a unit that is equipped with both GBS and S-TADIL J and an SBM is required. The experiment would involve sending an "email" User Pull request over S-TADIL J from the unit to the SBM. S-TADIL J "email" is not Internet email; it is used for trouble shooting and is not intended to be used in the same manner as Internet email. It is not SMTP compliant and would be used for the experiment only. The SBM would also need to be S-TADIL J capable. This is the case for the SBMs located at NCTAMS in Wahiawa and Norfolk. A concern is the location of the S-TADIL J receive terminal in relation to the GBS SBM within NCTAMS. When the SBM receives the User Pull request via S-TADIL J, the SBM would then broadcast the requested information via GBS for the unit that originated the request. Note that this experiment is designed to cue the broadcast not for browsing the web.

## B. TEST CONFIGURATION

The S-TADIL J user screen for "email" shown in Figure 12 indicates when the message is received by the unit the mail was sent to (i.e., NCTAMS/NCTS) and when the mail is actually opened by the receiving unit. The time the email was sent from the originating unit would also be recorded. The experiment would check the time from the

originating unit to NCTAMS and to the SBM specifically in addition to when the requested information was received via GBS by the requesting unit.

A Pacific Fleet surface platform that has both GBS and S-TADIL (e.g., USS BENFOLD after June 2000 will have both GBS and S-TADIL as shown in Appendix C.) The SBM for the Pacific AOR is NCTAMS Pacific in Wahiawa, Hawaii. Since USCINCPAC is prototyping GBS, there is a CONOPS in place; Standard Operating Procedures (SOPs) have also been drafted. The use of the GBS Product Request Form would need to be waived for the experiment.

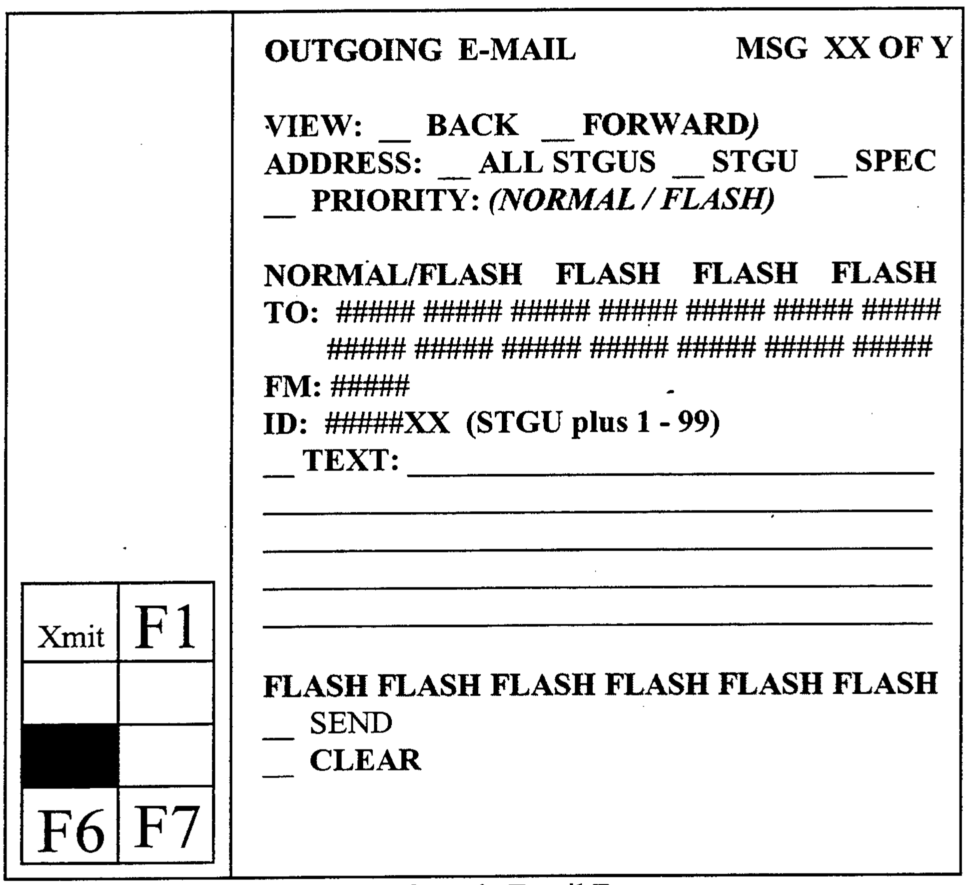

Figure 11. Sample Email Format
[Ref. 33]

## C. EXPERIMENT SETUP SUMMARY

The proposed experiment would involve sending an "email" over S-TADIL J from the surface platform to NCTAMS Pacific, Wahiawa, Hawaii requesting specific information products. The test will be timed from when the "email" leaves the surface platform until the information is broadcast on GBS. A preliminary test would involve testing the time required to send a message over S-TADIL J on the surface platform to NCTAMS Wahiawa.

# VI. EXPECTED TEST RESULTS

## A. DISCUSSION

GBS is described in the ORD as providing tactical and non-tactical products, however, some view it as a strategic vice tactical asset. Link 16 and S-TADIL J are viewed as true real-time tactical assets. Using S-TADIL J as a reach back for GBS may be viewed as a mismatch as far as optimal use of assets. The culture within the military may need to change as new systems come on line. Captain FitzSimonds describes this change below:

> The pace of information systems development suggests that the real challenge ahead, however, is not so much technological as organizational--that is, how best to organize people around these systems so as to exploit fully their capabilities. In his now-classic study of innovation in the U.S. Navy, Elting Morison observed that the introduction of a new technology into the military places in jeopardy--and indeed may even destroy--many long-standing 'mores and structures' of the established military society. He concluded that this cultural impact of organizational change has been the primary impediment to the exploitation of new technologies, often delaying by a generation or more even improvements commonly acknowledged to be in the best interest of the service. [Ref. 34]

In order to fully exploit GBS and what it can offer to the warrior, options for reach back such as S-TADIL J need to be considered from a technical aspect not from a doctrine standpoint. This view supports Network Centric Warfare and Joint Vision 2010. GBS can decrease the Observe-Orient-Decide-Act (OODA) loop by providing the warrior needed, timely information.

## B. OBSERVATIONS

Both GBS and S-TADIL J are relatively new systems. The reach back experiment would have to be scheduled after installation of both systems is complete (Appendix C).

## C. TOTAL TIME TO COMPLETE REACH BACK SESSION

When the experiment is conducted, Table 3 will be utilized to record the results of the tests. The expected time for the email to reach the NCTAMS is less than 20 seconds.

| Test Number | Time for email from surface platform to reach NCTAMS | Time for email from surface platform to reach SBM | Time for information to reach surface platform | Total test time |
|---|---|---|---|---|
| 1 | | | | |
| 2 | | | | |
| 3 | | | | |
| ... | | | | |

Table 3. Sample Test Results

# VII. CONCLUSIONS AND RECOMMENDATIONS

## A. CONCLUSIONS

S-TADIL J is a possible reach back option for GBS. Since all surface platforms that receive TADIL J will also have ADNS, a study should be conducted to compare both GBS reach back approaches (i.e., S-TADIL J and ADNS) in terms of performance, cost and scalability.

## B. RECOMMENDATIONS

Conduct the experiment using the email function of S-TADIL J. Exploring the viability of using S-TADIL J as a reach back option for GBS does not preclude the use of other reach back options, but provides an additional reach back option. As many reach back options as possible need to be explored due to varying capabilities from unit to unit and situation to situation. If an existing communication system is overutilized or not functional then another reach back option will still be available.

The PACOM SIPRNET web site is an extremely valuable tool to increase the visibility and use of GBS. As the Fleet becomes more aware of GBS and its capabilities, increased use and new uses will be become apparent allowing GBS to reach its full potential as a wide band information supplier.

## C. RECOMMENDATIONS FOR FUTURE RESEARCH

If the experiment shows that S-TADIL J is a viable reach back option for GBS, investigate the development of an interface between S-TADIL J and GBS. The interface

would need to link the S-TADIL J C2P and the GBS RBM on the shipboard side. The S-TADIL J terminal and GBS SBM at the NCTAMS would also need an interface. These interfaces would be unique to S-TADIL J. The goal is to achieve reach back via S-TADIL J in the fully connected mode. A J-series message could be developed to transmit the data required in the GBS Product Request Form. The experiment should also be conducted during an exercise that uses both GBS and S-TADIL J to simulate real-time operations. Additional the experiment should be conducted with NCTAMS Norfolk and NCTS Sigonella. There are preliminary plans for some of the functions of the SBM at NCTS Sigonella to be handled remotely from NCTAMS Norfolk. Since the SBM/PIP facility is not yet completed at NCTS Sigonella, the option of using S-TADIL J as a reach back option with NCTS Sigonella should be investigated at a later date.

# APPENDIX A. REACH BACK CONNECTIVITY MODES

[Ref. 7]

1. User Pull empowers users to deal directly with information producers using existing procedures to request information. The mode used to make the request depends on the user's GBS receive suite connectivity capabilities and the user's access to existing information systems. Use of receive suite feedback from terminals which are either fully or partially connected to provide quality of service feedback to the SBM will improve broadcast efficiencies, even if only a few representative terminals can act as proxies for others in the area of broadcast beams.

a. **Receive Only (RO) Mode.** In this mode, the receive suite can only receive the GBS broadcast. There is no manual or automatic communications channel available. In this case, the user has no means to request products to initiate User Pull.

b. **Manually Connected (MC) Mode.** In this mode, the receive suite can receive the GBS broadcast and the end user has access to some type of manual communications system. A human-in-the-loop is required for submitting user pull requests or requesting the rebroadcast of data products. In other words, the user calls in a request using whatever existing communications capability is available.

c. **Partially Connected (PC) Mode.** In this mode, the receive suite can receive the GBS broadcast and provide a means to transmit using standard protocols and applications, user pull or rebroadcast requests. The rebroadcast requests are automatically generated; however, full virtual duplex connectivity is not achieved and user pull is not automatically generated. The users must still request their products from the source by whatever means are available to them. The likelihood that the users are connected to some existing network is high and they will make their user pull requests via the various applications programs they have access to (e.g., SIPRNET and INTELINK).

d. **Fully Connected (FC) Mode.** In this mode, the receive suite can receive the GBS broadcast and a "return" channel exists over which rebroadcast requests are transmitted on a packet-per-packet basis using split protocols. The requests are automatically generated by the RBM and a virtual full-duplex connectivity is achieved. However, user pull is not automatically generated. The users must still request their products from the source by whatever means are available to them. The likelihood that the users are connected to some existing network is high and they will make their user pull requests via the various applications programs they have access to (e.g., SIPRNET and INTELINK).

2. In the future, we hope a more automated user pull network might be accessible to all users over GCCS or some other standard application that will simplify the user pull process.

# APPENDIX B. GBS PRODUCT REQUEST FORM

[Ref. 11]

*The GBS Product Request form is intended for users, installers, etc to request specific support for their GBS Receive Suites; it should be used when adding, dropping, or changing products, when there is a change in operational status or user location, and/or when there is a change in the support window. The form can be submitted to the servicing Satellite Broadcast Manager (see Note 1 for contact details) by email or fax, or the information can be incorporated into an AUTODIN or DMS message. The form should be submitted as far in advance as possible, and updated as new information becomes available.*

**Date Time Group (DTG) of Request (GMT):** ____________ **DTG of Previous Request (if any)** ____________

**Name:** ____________ **Title:** ____________ **Organization/ UIC:** ____________

**Commercial Tel:** ____________

**DSN Tel:** ____________

**Email:** ____________

**AUTODIN Address (if Applicable):** ____________

**Type of Request:** Add Product ____ Delete Product ____ Change a Product ____ Change Support Window ____

Other ____ ____ Change Location ____ Change User Operational Status ____

**General Location Where Products are Required:*** ____________

**** Classified PIM data or deployment location should be provided under separate cover via SIPRNET or AUTODIN/DMS Message to the servicing SBM.***

**Timeframe (GMT) when Products are Required:** ____________

**Associated Task Force or Battle Group, if applicable:** ____________

**Associated Mission or Exercise, if applicable** ____________

## REQUESTED PRODUCT INFORMATION

| Originator/URL (if known) | Content | Priority ( Note 2) | Format ( Note 3) | Anticipated Classification | Anticipated Keymat | Confirm Keymat Held by User | Periodicity of Transmission |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |

**Comments:**

Note 1:
**SBM Contact Information**

**UFO-8 SBM (Wahiawa, HI)**

| | | |
|---|---|---|
| **Hours of Operation** | The Help Desk hours of operations depend on current activities. During unstaffed hours, a voice mail system is available to leave a message for the Help Desk or a specific member of the SBM staff | |
| **Help Desk** | Commercial: (808) 653-5050 | DSN: 453-5050 |
| **Secure calls via STU-III** | Commercial: (808) 653-5050 | DSN: 453-5050 |
| **Unclassified FAX** | Commercial: (808) 653-7490 | DSN: 453-7490 |
| **Secure FAX** | Not available at this time. | |
| **Note** | The help desk phone system is in the process of being upgraded. Once complete, the 653-5050 number will forward to the next available line at the SBM. We only wish to publish the one telephone number. Until the upgrade is complete, users may periodically receive a busy signal when calling into the SBM. | |
| **Unclassified email** | helpdesk@gbs-pacom.navy.mil | |
| **SIPRNET email** | helpdesk@gbs-pacom.navy.smil.mil | |

**UFO-9 SBM (Norfolk VA)**

| | | |
|---|---|---|
| **Hours of Operation** | The Help Desk hours of operations depend on current activities. During unstaffed hours, a voice mail system is available to leave a message for the Help Desk or a specific member of the SBM staff | |
| **Help Desk** | Commercial: (757) 444-9190 | DSN: 564-9190 |
| **Secure calls via STU-III** | Commercial: (757) 444-8981/8993 | DSN: 564-8981/8993 |
| **Unclassified FAX** | Commercial: (757) 444-9158 | DSN: 564-9158 |
| **Secure FAX** | Not available at this time. | |
| **Note** | The help desk phone system is in the process of being upgraded. Once complete, the 444-9190 number will forward to the next available line at the SBM. We only wish to publish the one telephone number. Until the upgrade is complete, users may periodically receive a busy signal when calling into the SBM. | |
| **Unclassified email** | helpdesk@gbs-norfolk.navy.mil | |
| **SIPRNET email** | helpdesk@gbs-norfolk.navy.smil.mil | |

**UFO-10 SBM (Sigonella Italy)**

| | | |
|---|---|---|
| **Hours of Operation** | TBD | |
| **Help Desk** | Commercial: TBD | DSN: TBD |
| **Secure calls via STU-III** | Commercial: TBD | DSN: TBD |
| **Unclassified FAX** | Commercial: TBD | DSN: TBD |
| **Secure FAX** | TBD | |
| **Unclassified email** | TBD | |
| **SIPRNET email** | TBD | |

Note 2:

**JCS Priority**

Indicates the operational priority of the network as defined in CJCSI 6250.01. The priority of the product should be submitted as low as possible. Values are:

| | |
|---|---|
| **Priority 0.** | **Assigned only by NCA/CJCS for emergent critical contingency support** |
| **Priority 1** | **Strategic Order (essential to national survival)** |
| 1A | System Control/Orderwire |
| 1B | National Command Authorities |
| 1B1 | Presidential Support |
| 1B2 | SECDEF Support |
| 1B3 | Envoy and Emissary Support |
| 1C | Strategic and Threat Warning/Intelligence |
| 1D | SIOP/Force Direction Requirements |
| **Priority 2** | **Warfighting Requirements** |
| 2A | Department of State Diplomatic Negotiations |
| 2B | CJCS Support |
| 2C | CINC Operations |
| 2D | JTF/CTF Operations |
| 2E | Component Operations (Theater Forces) |
| 2F | Tactical Warning and Intelligence |
| 2G | CJCS Sponsored Selected Exercises |
| 2H | Counter-narcotics Operations |
| **Priority 3** | **Essential Non-Warfighting Operational Support** |
| 3A | Humanitarian Support |
| 3B | Intelligence and Weather |
| 3C | Logistics Support |
| 3D | Radio Frequency Interference (RFI) Resolution |
| 3E | Diplomatic Post Support |
| 3F | Space Vehicle Support |
| 3G | Other Service Support |
| **Priority 4** | **Training** |
| 4A | CJCS Sponsored |
| 4B | CINC Sponsored |
| 4C | MAJCOM/MACOM/Echelon Two Sponsored |
| 4D | Unit Sponsored |
| **Priority 5** | **VIP Support** |
| 5A | Service Secretaries |
| 5B | Service Chiefs |
| 5C | CINC Travel |
| 5D | Other Travel |
| **Priority 6** | **RDT&E and General** |
| 6A | DOD-Sponsored Testing |
| 6B | DOD-Sponsored Demonstrations |
| 6C | DOD Administrative Support |
| 6D | DOD Quality of Life Initiatives |
| **Priority 7** | **Miscellaneous** |
| 7A | DOD Support to Law Enforcement |
| 7B | Other Non-DOD Support |
| 7C | Non-US Support as approved by the authorized organization |
| 7D | Other |

Note 3:

**Formats may include*:**

**Streamed Data Services**
- Synchronous Serial
- UNCLAS Audio/Video

**Data File Services**
- Email
- File Transfer
- Web Service

**Network Stream Services**
- IP Multicast
- Internet
- COP

***Check with servicing SBM to confirm Current availability of formats***

# APPENDIX C. GBS EQUIPPED PLATFORMS VS S-TAIDL J EQUIPPED PLATFORMS

[Ref. 27, 35]

The table below is provided to compare surface platforms that will have GBS installed during FY 00 with units that will have S-TADIL J installed through FY 01. During future years, GBS installations will be down to the DDG level for Battle Groups (BG) and Amphibious Readiness Groups (ARG), which means that most CV/Ns, CGs, DDGs, LHA/Ds, LPDs and LSDs will have GBS. This corresponds to the surface platforms that will also receive S-TADIL J.

| **PLATFORM** | | **GBS** | **S-TADIL J** |
|---|---|---|---|
| **KITTY HAWK/ESSEX** | | | |
| CV-63 | KITTY HAWK | MAR 00 | FY 01 |
| CG-53 | MOBILE BAY | MAY 00 | NOV 99 |
| CG-49 | VINCENNES | MAR 00 | |
| CG-62 | CHANCELLORSVILLE | MAR 00 | FY 01 |
| CG-63 | COWPENS | MAR 00 | FY 00 |
| DDG-56 | JOHN S. McCAIN | APR 00 | DEC 01 |
| LHD-2 | ESSEX | APR 00 | FY 01 |
| **COMMAND SHIPS** | | | |
| LCC-20 | MT WHITNEY | MAR 00 | |
| AGF-11 | CORONADO | FEB 00 | |
| LCC-19 | BLUE RIDGE | APR 00 | |
| AGF-3 | LA SELLE | MAY 00 | |
| **TRUMAN/NASSAU** | | | |
| CVN-75 | TRUMAN | FEB 00 | JAN 00 |
| CG-56 | SAN JACINTO | FEB 00 | DEC 99 |
| DDG-51 | ARLEIGH BURKE | FEB 00 | JUN 00 |
| DDG-57 | MITSCHER | FEB 00 | JUN 00 |
| DDG-78 | PORTER | FEB 00 | JUN 00 |
| LHA-4 | NASSAU | MAR 00 | |

| | | | |
|---|---|---|---|
| **CONSTELLATION/BOXER** | | | |
| CV-64 | CONSTELLATION | | FEB 00 |
| CG-65 | CHOSIN | APR 00 | JUN 00 |
| CG-70 | LAKE ERIE | APR 00 | JUN 00 |
| DDG-65 | BENFOLD | APR 00 | JUN 00 |
| DD-965 | KINKAID | APR 00 | |
| LHD-4 | BOXER | APR 00 | |
| **ENTERPRISE/KEARSARGE** | | | |
| CVN-65 | ENTERPRISE | MAY 00 | NOV 99 |
| CG-58 | PHILIPPINE SEA | MAY 00 | JUN 00 |
| CG-64 | GETTYSBURG | MAY 00 | JUN 00 |
| DD-982 | NICHOLSON | MAY 00 | |
| LHD-3 | KEARSARGE | MAY 00 | MAR 00 |
| **VINSON/PELEIU** | | | |
| CVN-70 | CARL VINSON | JUN 00 | JUN 00 |
| CG-54 | ANTIETAM | JUN 00 | DEC 99 |
| CG-59 | PRINCETON | JUN 00 | FY 00 |
| DDG-77 | O'KANE | JUN 00 | JUN 00 |
| DD-971 | DAVID R RAY | JUN 00 | |
| LHA-5 | PELELIU | JUN 00 | |
| **ROOSEVELT/BATAAN** | | | |
| CVN-71 | ROOSEVELT | JUN 00 | JUL 00 |
| CG-55 | LEYTE GULF | JUN 00 | JUN 00 |
| CG-72 | VELLA GULF | JUL 00 | JUN 00 |
| DD-997 | HAYLER | JUL 00 | |
| DDG-71 | ROSS | JUL 00 | JUN 00 |
| LHD-5 | BATAAN | JUL 00 | FY 01 |
| **OTHER** | | | |
| CG-67 | SHILOH | JAN 00 | MAY 01 |
| CVN-74 | STENNIS | | INSTALLED |
| CG-57 | LAKE CHAMPLAIN | | INSTALLED |
| CG-68 | ANZIO | | INSTALLED |
| CG-71 | CAPE ST GEORGE | | INSTALLED |

| | | | |
|---|---|---|---|
| LHD-6 | B H RICHARD | | INSTALLED |
| CVN-72 | ABRAHAM LINCOLN | | DEC 99 |
| CVN-73 | G WASHINGTON | | NOV 99 |
| CG-52 | BUNKER HILL | | OCT 99 |
| CG-73 | PORT ROYAL | | NOV 00 |
| DDG-53 | JOHN PAUL JONES | | JUL 00 |
| DDG-55 | STOUT | | JUN 00 |
| DDG-59 | RUSSELL | | FY 00 |
| DDG-60 | PAUL HAMILTON | | FY 00 |
| DDG-63 | STETHAM | | JUN 00 |
| DDG-64 | CARNEY | | JUL 00 |
| DDG-66 | GONZALEZ | | FY 00 |
| DDG-74 | MCFAUL | | JUN 00 |
| CG-60 | NORMANDY | | FY 01 |
| CG-61 | MONTEREY | | FY 01 |
| DDG-54 | CURTIS WILBUR | | NOV 01 |
| DDG-62 | FITZGERALD | | SEP 01 |
| DDG-67 | COLE | | APR 01 |
| DDG-68 | THE SULLIVANS | | FY 01 |
| DDG-69 | MILIUS | | MAR 01 |
| DDG-70 | HOPPER | | MAR 01 |
| DDG-73 | DECATUR | | MAR 01 |
| DDG-75 | DONALD COOK | | MAY 01 |
| DDG-76 | HIGGINS | | AUG 01 |

## LIST OF REFERENCES


1. Teledesic Web Site, [http://www.teledesic.com]. August 1999.

2. *Joint Staff Mission Need Statement (MNS) for Global Broadcast Service (GBS)*, 8 August 1995.

3. "USCINCPAC Operational Walk-through" brief presented by CAPT Delpino, USN, GBS Program Manager on 28 January 1998.

4. DIRECTV Web Site, [http://www.directv.com]. July 1999.

5. DirecPC Web Site, [http://www.direcpc.com]. July 1999.

6. Headquarters United States Pacific Command, *United States Pacific Command Global Broadcast Service Concept of Operations*, 3 December 1998.

7. Joint Staff, *Global Broadcast Service Joint Concept of Operations*, Version 2.0, 31 December 1997.

8. "Information Briefing Global Broadcast Service (GBS)" brief presented by Major Robert Cruz, HQ USCINCPAC J6337 on 19 April 1999.

9. "Global Broadcast Service (GBS) Shipboard Information Services Interfaces," brief presented at GBS Working Group Meeting on 23 February 1998 by Dr. Roy Axford, Jr. SPAWARSYSCEN-SD, D841.

10. Joint Staff, *Global Broadcast Service (GBS) Theater Injection Point (TIP) Concept of Operations*, Annex T, 19 May 1999.

11. GBS Joint Program Web Site, [http://www.laafb.af.mil/SMC/MC/GBS]. September 1999.

12. "A Demonstration of High Data Rate and Medium Data Rate Backchannel Potential for the Global Broadcast System," [http://w3.nrl.navy.mil/projects/HDRSATCOM/gbs1.html]. July 1999.

13. Joint Requirements Oversight Council (JROC) *Operational Requirements Document (ORD) for Global Broadcast System (GBS)*, 7 April 1997.

14. Headquarters United States Pacific Command, Standard Operating Procedures for Global Broadcast Service - Draft, 16 June 1999.

15. Arthur, Joseph E., *Global Broadcast Service Reach Back Via Ultra High Frequency Demand Assigned Multiple Access Satellite Communications*, Master's Thesis, Naval Postgraduate School, Monterey, California, June 1998.

16. Krout, Timothy, et. al, "WWW Browsing Using GBS – Asymmetric Networking," Naval Research Laboratory, proceedings of MILCOM 98, October 1998.

17. Misiewicz, Michael V. K., *Modeling and Simulation of a Global Broadcasting Service Reach Back Architecture for Information Dissemination Management*, Master's Thesis, Naval Postgraduate School, Monterey, California, September 1998.

18. J6 Joint Staff Washington DC Naval Message, Subject: Status and Request for Support for Global Broadcast Service (GBS) Operations in PACOM, 101600Z June 1999.

19. "Global Broadcast Service (GBS) Increment One Enhanced (GBS I1E) Performance Test 19-30 June 1999" brief updated 18 August 1999.

20. CNO Project (J 1555) GBS I1E Performance Test for the Navy Global Broadcast Service (GBS) Receive Suite Situation Report (SITREP) No. Five (Second Send).

21. Krout, Timothy, et. al., "The Effects Of Asymmetric Satellite Networks on Protocols," Naval Research Laboratory, proceedings of MILCOM 98, October 1998.

22. Krout, Timothy, "CINCPAC/J2 Asymmetric Networking using GBS UFO 8," Naval Research Laboratory, not dated.

23. Hughes Spaceway™ "Wireless Broadband on Demand," [http://www.hns.com/spaceway/spaceway.htm]. July 1999.

24. *Link 16 Operational Specification OS-516.2*, Published under the direction of CNO (N62) by Navy Center for Tactical Systems Interoperability, July 1998.

25. Logicon, Inc., "Understanding Link-16," CD-ROM, 1995.

26. "Introduction to Link 16 Operations" brief prepared by SPAWAR, not dated.

27. COMSPAWARSYSCOM San Diego CA (PMW 159) Naval Message, Subject: Advanced Tactical Data Link Systems (ATDLS) Fielding Plan, 201659Z August 1999.

28. *C2P (S-TADIL J) Handbook*, Space and Naval Warfare Systems Center, C2P Project Office, Code D4523, Revision 6, June 1998.

29. (IDD) *Interface Design Description for S-TADIL J*, prepared by Questech, Inc. for Naval Command, Command, Control and Ocean Surveillance Center, 1 October 1996.

30. SSC San Diego Command Brief, Space and Naval Warfare Systems Center San Diego, CA, September 1998.

31. Chairman Joint Chiefs of Staff Instruction CJCSI 6250.01, *Satellite Communications*, 28 October 1998.

32. "UHF DAMA" brief developed by Joint DAMA Implementation Working Group (JDIWG), September 1996.

33. "S-TADIL J Email Design," brief prepared by Tim Downing, SPAWAR, 26 December 1996.

34. FitzSimonds, CAPT James R., USN, "The Cultural Challenge of Information Technology," *Naval War College Review*, Summer 1998.

35. Email from Patrick Costello, Lieutenant Commander, USN, Assistant for EHF, GBS and Advanced SATCOM Systems, CNO N612C, Washington, D.C., and the author, 30 August 1999 and 7 September 1999.

## INITIAL DISTRIBUTION LIST

1. Defense Technical Information Center ........................................ 2
   8725 John J. Kingman Road, STE 0944
   Fort Belvoir, VA 22060-6218

2. Dudley Knox Library ........................................ 2
   Naval Postgraduate School
   411 Dyer Road
   Monterey, CA 93943-5101

3. LCDR Patrick Costello ........................................ 1
   Chief of Naval Operations
   N-612
   2000 Navy Pentagon
   Washington, DC 20350-2000

4. Dr. Roy Axford ........................................ 1
   Space & Naval Warfare Systems Center
   Code D841 (Advanced Concepts Branch)
   53560 Hull Street
   San Diego, CA 92152-5001

5. Chairman, Code IS ........................................ 1
   Naval Postgraduate School
   Monterey, CA 93943

6. Professor Rasler W. Smith, Code EC/Sr ........................................ 1
   Naval Postgraduate School
   Monterey, CA 93943

7. Professor Rex A. Buddenberg, Code ISAG ........................................ 1
   Naval Postgraduate School
   Monterey, CA 93943

8. LCDR Sandra Fenton ........................................ 1
   416 Fountain Avenue
   Pacific Grove, CA 93950